

the invention. Specifically, the Examiner point to the terms "distances are set such that upon application of the heat treatment to the device, the bumps of the first bump unit melt so as to become connected and fuse to each other as a unitary body," in claims 26, and "bumps of the first bump unit are sufficiently close to each other that upon the application of the heat treatment to the device, the bumps of the first bump unit fuse into a unitary body," in claim 28, as being relative terms that render the claims indefinite. The Examiner argues that the terms are not defined by the claim, the specification does not provide a standard for ascertaining the requisite degree, and one of ordinary skill in the art would not be reasonably apprised of the scope of the invention.

The rejection is respectfully traversed. The terms in the claims to which the Examiner refers constitute functional limitations, i.e., defining a feature of the invention by what it does, rather than what is, such as its specific structure or composition. As indicated in MPEP §2173.05(g), there is nothing inherently improper with defining some part of an invention in functional terms. Functional language does not, in out itself, render a claim indefinite. The question to be considered, just as with any other claim limitation, is what the limitation fairly conveys to a person of ordinary skill in the pertinent art in the context in which it is used. It is respectfully submitted that, in this case, a person of ordinary skill in the art could readily determine what spacing, or range of spacings, of the bumps in the first bump unit would be sufficiently close such that the bumps would fuse into a unitary body upon application of the heat treatment. Contrary to the Examiner's argument, the specification does provide, on page 5, lines 26-28, an example of when the bumps in the first bump unit could be considered "sufficiently close." In fact, the Examiner himself argues, in connection with claim 31 (see page 6 of the Action), that it would have been an obvious matter of design choice to make the distance between the bumps in the bump first bump unit about 1 to 1.4 times the diameter of the bumps, since such a changes in size is generally recognized as being within the level of ordinary skill in the art. Hence, is respectfully submitted that claims 26 and 28 are not indefinite under the standards enunciated in MPEP §§2173.05(b) and 2173.05(g).

In the latest Office Action, the Examiner agues in the alternative (see page 2 of the Action) that the limitation in question is inherently known in the art as "a collapse of solder balls," which is mainly avoided in modern chip designs by so-called "collapse

proof" technologies. It is respectfully submitted that the teaching to which Examiner refers is applicable to the peripheral area in which it is desirable to prevent adjacent signal leads from shorting together when the solder balls are heated and reflow to attach the semiconductor assembly to a printed circuit board. That much is disclosed in the present application. However, while the phenomenon of solder balls shorting when they are placed too close together may be known, neither Katchmar nor Bond suggests the advantage, in terms of the resulting heat flow efficiency, of spacing solder ball so close together that they fuse into a unitary body when heated. If anything, the "collapse proof" technology referred to by the Examiner teaches away from the present invention. Further the present invention advantageously allows the same size solder balls to be used both in the central area and in the peripheral area when the semiconductor device is being fabricated. This reduces manufacturing cost and time as compared to procuring and attaching a separate solder mass for heat conduction, as in Katchmar (e.g., item 26 of Katchmar Figure 4).

For the foregoing reasons, reconsideration and withdrawal of the Examiner's §112, second paragraph, rejection is respectfully requested.

Claims 20, 22 and 24-29 and 31 stand rejected under 35 USC §103(a) as being obvious over Katchmar (U.S. Patent No. 6,194,782 B1), in view of Bond et al. (U.S. Patent No. 5,642,261). The rejection is respectfully traversed.

In the current Action, the Examiner asserts that Katchmar teaches a semiconductor device, Figures 1-5, comprising: a substrate 12 having a main surface 14 and a back surface 16, wherein said back surface 16 has a central area 32, an intermediate area surrounding said central area 32 and a peripheral area surrounding said intermediate area; a semiconductor chip 18 formed on said main surface; a first bump unit formed of solder bumps 40 (Figure 5) disposed at a first distance from each other and located in said central area of said back surface, wherein said first bump unit radiates heat from said semiconductor device; a second bump unit formed of solder bumps 24 and located in said peripheral area of said back surface, wherein said second bump unit transmits signals (column 6, lines 50-53), wherein the second bump unit is greater in quantity of solder balls than the first bump unit, and said solder balls are spherical in shape. Further, the Examiner asserts that Katchmar teaches a first distance between connection solder balls being greater than a second distance between heat transfer solder balls (column 7, lines 39-47). Further

yet, the Examiner points to Katchmar as teaching that said central area could be thermally connected to said circuit board by a solid melted solder mass 26.

Contrary to the Examiner's assertions, it is respectfully submitted that Katchmar fails to teach or suggest a distinct intermediate area between the central area and the peripheral area, as required by the rejected claims. What Figures 1-4 disclose, for example, is a ball grid array with uniform spacing in which the solder mass 26 replaces the solder balls in the area under the semiconductor chip 18, and only in that area, and the remainder of the bottom surface 16 of the substrate 12 comprises a peripheral area, available for placement of solder balls (column 6, line 66, through column 7, line 3) for signal transmission purposes. In Figure 5 of Katchmar, a plurality of closely spaced solder balls 40 replaces the single solder mass 26 under the semiconductor chip (column 7, lines 39-48). However, unlike the present invention, none of the embodiments described in Katchmar disclose a distinct intermediate area, marked by a lack of solder balls, between the central area and the peripheral area.

The Examiner acknowledges that Katchmar fails to teach that the second distance (between the bumps of the second bump unit) is less than the width of the intermediate area, and that the melted solder mass (unitary body) can be made by locating bumps of the first bump unit sufficiently close to each other that upon application of the heat treatment to the device, the bumps of the first bump unit will fuse together. To cure this defect in Katchmar, the Examiner points to Bond as teaching a semiconductor device 8, Figures 1-6, comprising: a substrate 14 having a main surface and a back surface, wherein the back surface has a central area, an intermediate area surrounding the central area, and a peripheral area surrounding the intermediate area; a semiconductor chip 10 formed on the main surface; a first bump unit formed of solder bumps 18 disposed at a first distance apart from each other, and located in the central area of the back surface, wherein the first bump unit radiates heat from the semiconductor device; a second bump unit formed of solder bumps disposed at a second distance apart from each other and located in the peripheral area of the back surface, wherein the second bump unit transmits signals, the second distance is greater than the first distance, the second distance is less than a width of the intermediate area, and the second bump unit is greater in quantity of solder balls than the first bump unit, the solder balls being spherical in shape. The Examiner also asserts that

Bond discloses in Figure 2, bumps 18 of the first (central) bump unit located so close to each other that upon application of the heat treatment to the device, they will obviously fuse into a unitary body. The Examiner argues that it would have been obvious to one skilled in the art at the time the invention was made to employ a second distance being less than a width of the intermediate area, and to locate bumps of the first bump unit so close to each other that upon application the heat treatment to the device the bumps of the first bump unit will fuse into a unitary body as shown by Bond in the device of Katchmar in order to avoid shorting between the thermal and signal solder balls while applying heat to melt the thermal solder balls into a unitary body, and to enhance heat dissipation by a central group of solder balls.

While the Examiner has been maintaining that the space between the bumps in the central area and the bumps of the peripheral area in Katchmar and Bond correspond to the intermediate area recited in the claims, it is respectfully submitted that there is nothing about that space to distinguish it from the peripheral area or to indicate that is if not simply part of the peripheral area itself. There is nothing disclosed in the text of Katchmar to suggest an intermediate area; only that the solder balls under the semiconductor die (i.e., in the central area) are placed in closer proximity to each other than those not positioned under the die (i.e., in the peripheral area) (see column 7, lines 42-44).

Contrary to the Examiner's position, it is respectfully submitted that Figure 1 of Bond also discloses that the space between the central area and the peripheral area is indistinguishable from the peripheral area itself. The text and figures of Bond fail to disclose an intermediate area; they disclose only that the area under the slug 12 has solder balls 18 to conduct heat away from the semiconductor die 10 (column 4, line is 34-37), and the area not under the slug has an array of solder balls to provide signal connections (column 4, lines 12-20). Unlike Katchmar, Bond fails entirely to disclose any relationship between the spacing of solder balls in the peripheral and central areas. By contrast, the present application, in Figures 1 & 2, discloses a very well-defined intermediate area in which no bumps are disposed and having a width distinctly larger than the space between the solder balls in the peripheral area.

As noted above, the Examiner relies on Bond to satisfy the requirement that the bumps of the first bump group melt and fuse together upon application of heat. It is

respectfully submitted that the solder balls under the integrated circuit chip are shown out of scale for clarity in the plan view of Figure 2 of Bond, and that the more accurate representation is the section view of the same embodiment in Figure 1 of Bond, where the solder balls in the central area do not appear to be any closer together than those in the peripheral region. There is nothing elsewhere in Bond to even suggest having the solder balls in the central area close enough together to melt and form a unitary body when heat is applied. In fact, the embodiments shown in Figures 3-6 of Bond utilize solder masks 37, 81 that would prevent the formation of a unitary body of solder. Thus, if anything, Bond teaches away from this advantageous feature of the present invention.


Considering the foregoing, it is respectfully submitted that Bond fails to cure the acknowledged defects in Katchmar, and that claims 20, 26 and 28, as well as their respective dependent claims, distinguish over the applied art references, whether taken individually or in combination.

All of the claim rejections having been addressed, it is respectfully submitted that the application is in condition for allowance. Notice of such, with allowed claims 20, 22 and 24-29 and 31, is earnestly solicited.

In view of the protracted prosecution of this application and the number of iterations through which the examination process has passed, an interview at this time may be helpful in resolving the outstanding issues. The Examiner is respectfully invited to call the undersigned attorney to schedule such an interview.

Respectfully submitted,

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Date

  
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AMENDMENT

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